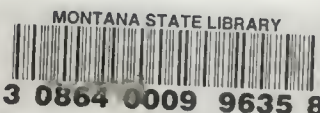


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vicinity of Storm  
Lake, Deerlodge



SURVEY FOR *BOTRYCHIUM PARADOXUM*  
IN THE VICINITY OF STORM LAKE,  
DEERLODGE NATIONAL FOREST

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## INTRODUCTION

*Botrychium paradoxum* Wagner was first described based on nine plants collected from a meadow on the shore of Storm Lake on the Deerlodge National Forest, in Deerlodge County, Montana (Wagner and Wagner 1981). Plants could not be found at the type locality in searches conducted in 1985 by Peter Lesica, but were rediscovered and surveyed by the Deerlodge National Forest botanist, Susan Rinehart, and others (Dana Field, John Harmann, Sherry Vogel) in 1992.

*B. paradoxum*, commonly called peculiar or leafless moonwort, is in the Ophioglossaceae, a family of primitive ferns (sometimes considered fern allies). Moonworts have their center of diversity in the mountains of western North America (Wagner and Wagner 1983). They are usually characterized morphologically by a single sterile frond (trophophore) and a single fertile frond (sporophore), however, *B. paradoxum* possesses two sporophores but no trophophore. Moonworts are minute plants which are easily overlooked by botanists and other field workers.

Prior to 1993, four very small populations of this species were known from Montana and included in the Biological Conservation Database maintained by the Montana Natural Heritage Program: 1) Storm Lake with 20+ plants counted 2) Swiftcurrent Lake in Glacier National Park with 2, 3) East of Marias Pass near the Glacier-Pondera County line with 45, and 4) Our Lake in the Front Range in Teton County with 30. The current status of the Swiftcurrent site is unknown, the Marias Pass population has been unsuccessfully sought, and the Our Lake population is being studied by the Lewis and Clark National Forest. In addition, verification is pending of a reported 1993 collection made of this species in Kootenai National Forest (Leavell pers. commun.). Outside of Montana, the species is known from southern Utah (Wagner et al. 1984), northeastern Oregon (W. Wagner, pers. commun.) and Alberta, British Columbia, and Saskatchewan, Canada (Argus and Pryor 1990).

The Montana Natural Heritage Program (MTHP) maintains a list of Montana Plant Species of Special Concern (Heidel and Poole 1993) in which *B. paradoxum* is categorized as G1 and S1, meaning that the species is "critically imperiled due to extreme rarity," both globally and within the state. The U.S.D.I. Fish and Wildlife Service (1993) designates the species as C2, indicating that more information is needed to justify either listing as endangered or threatened, or removal from consideration. The U.S. Forest Service lists the species as "sensitive" (USDA Forest Service 1989).



In the summer of 1993, the Storm Lake area was surveyed to learn more about the population and to attempt to discover new occurrences of *B. paradoxum*. This paper describes the methods and results of this project and incorporates information from previous reports to serve as a summary of the species' known status on the Deerlodge National Forest. It also serves as a prototype for expanded survey and species status summary.

## METHODS

Field surveys for *Botrychium paradoxum* were conducted on the Deerlodge National Forest and adjacent lands in the immediate and general vicinity of Storm Lake on July 30 through August 5, 1993. On July 30, Sherry Vogel showed me where the species had been relocated the previous summer and we tried to estimate the size of the population and characterize the habitat where it occurs. A method for surveying these extremely inconspicuous plants began to evolve. The searcher stoops, sits, or kneels (usually the latter) in putative moonwort habitat and closely scans a swath of ground, crawling along and moving "overstory" graminoids and forbs aside with her/his hands until a *Botrychium* (of any species) is found or the search is abandoned. If a single plant is found, then further, more intensive search is warranted. Plants of each *Botrychium* species encountered are counted separately and search continues for a certain amount of time, then the searcher moves on. No attempt is made to count every plant in a given area; this would require a huge amount of time, and would result in excessive trampling of the population. Crude and relative estimates of population density, numbers, and boundaries, and community composition can be based on the numbers of moonworts counted per unit time across a certain area. Different adjacent habitats (wet meadows, dry rocky meadows, and coniferous forests) were searched in this manner to determine the ecological amplitude of the species. Subsequent surveys concentrated on mesic openings and meadows, the only habitat where *B. paradoxum* was found around Storm Lake.

During the following week, searches were conducted in the Storm Lake basin and around other sub-alpine lakes within a few miles, according to Susan Rinehart's (1992) recommendations, and other locations in the vicinity were explored. A ridgetop meadow ("Windy Ridge") was surveyed based on the appearance of "potential" habitat in the distance while driving. On August 3, Steve Shelly and John Joy helped survey a population of *B. paradoxum* which was discovered there the previous evening. One Hundred Acre Meadow was searched at





the suggestion of Steve Shelly. Due to success in finding new populations, and the time dedicated to surveying them, only a small proportion of the Forest was explored, all within a six mile radius of Storm Lake. Figures 1-4 in Appendix A are maps showing travel routes and the areas which were intensely searched.

Whenever *B. paradoxum* was found, the population was surveyed, mapped, and photographed. Notes were taken on population biology (numbers, boundaries, phenology) and habitat (associated vegetation, slope, soil, etc...) and standard field survey forms were filled out. Photographs were taken of the plants and habitat with an Olympus OM-1 camera with a standard 50 mm lens (with or without screw on close up lenses) on Kodachrome 64 ASA slide film. Usually a translucent plastic bag was draped over the overstory vegetation to eliminate shadows. Additional slides were contributed by John Joy. A limited number of specimens of *B. paradoxum* and other *Botrychium* species were collected, pressed, and dried as population size reasonably allowed. Collections were also made of associated flowering plants when positive field identification was difficult or impossible or when surveying poorly botanized areas (e.g. One Hundred Acre Meadow). All specimens will be identified, labeled, and deposited in herbaria (MONT in Bozeman will receive the first set). The *Botrychium* specimens were taken to Mike Windham, a fern specialist at the University of Utah, who offered tentative determinations. Dr. W. H. Wagner Jr., the world's foremost "botrychiologist," was asked to verify determinations but was reluctant to accept specimens due to a large backlog, however, he was able to make comments based on slides of living plants and photocopies of the specimens.

## RESULTS

This project significantly expands the populations and numbers of *Botrychium paradoxum* known to exist. The main Storm Lake population was found to consist of more individuals and to cover more ground than previously reported and two subpopulations within the same basin were located for the first time. In addition, new populations at "Windy Ridge" (called so by locals, but not on maps) and One Hundred Acre Meadow were found. The population on Windy Ridge represents by far the largest population of this species reported to date.

There is a tendency for species of *Botrychium* to grow in mixed populations which have been called "genus communities" (Wagner and Wagner 1983). At all three *B. paradoxum* sites on



the Deerlodge, other species of moonworts were also found. At Storm Lake, Rinehart (1992), referring to Hitchcock and Cronquist's (1973) key, recognized four species: *B. lunaria* var. *lunaria*, *B. lunaria* var. *onadandagense*, *B. boreale*, and an undetermined species. Although the identification of *B. paradoxum* is quite straight forward, distinctions between some of the other species are often subtle, and taxonomic treatments vary greatly between floras. The most recent treatment of the genus by the Wagners (1993) is the system adopted here.

Tentative determinations (after consultation with Wagner and Windham) of my own collections and photographs indicate co-occurrences of *B. paradoxum* with *B. lunaria*, *B. pinnatum* (probably the same plant Rinehart called *B. boreale*), *B. minganense*, and *B. crenulatum*; these last two are Montana Plant Species of Special Concern and either could be the plants Rinehart called *B. lunaria* var. *onadandagense*. In addition, a strange undescribed plant was collected on Windy Ridge; this is a one fronded *Botrychium* with very small, but regular spores, which lacks both a trophophore and a second sporophore (slide # 19, Appendix F). Also at Windy Ridge, Steve Shelly collected *B. lunaria* and a probable sterile hybrid, morphologically distinguished by the development of sporangia on the margins of the "sterile" lamina, and deformed spores. A similar hybrid (*B. X watertonense*) between *B. paradoxum* and *B. hesperium*, has been described from Alberta (Wagner et al. 1984). Photocopies of all our *Botrychium* collections with label data are included in this report as Appendix E. Close-up slides of the plants are included in Appendix F.

To facilitate incorporation of this paper into a future status report on *B. paradoxum* for the U. S. Fish and Wildlife Service, further information on the Deerlodge National Forest populations is presented here under the standard topic headings of geographic distribution, environment and habitat, population biology, and evidence of threats to survival. The standard format within those headings, however, is not strictly followed. Appropriate information from previous reports on the Storm Lake population, species biology, and other background is presented and cited in these sections along with the results of the current study.

## 1. Geographic distribution

As summarized above, three populations of *B. paradoxum* are now known from the Deerlodge National Forest. They are located in the northern part of the Anaconda Range, south of Georgetown Lake in Deerlodge and Granite Counties. The population at One Hundred Acre Meadow is mostly within the boundaries of the Anaconda-Pintlar Wilderness Area, and the





Storm Lake population lies just outside the Wilderness. All three sites were surveyed by this project and no others are historically known from the Forest. Areas which were intensely searched but where no *B. paradoxum* was found include meadows in the Storm Lake, Twin Lakes, and Upper Seymour Lake basins, and habitat adjacent to the One Hundred Acre Meadow and Storm Lake populations; these search locations are mapped in Figures 1-4 in Appendix A. The locations of the three known populations are mapped in Figures 5-7 in Appendix B. Their precise locations are as follows:

Site name: Storm Lake

County: Deerlodge

Legal description: T4N R13W S30 NW1/4 and NE 1/4, S29 SW1/4

Elevation: 8,200-8,500 ft.

Directions: About 12 miles west of Anaconda on State Highway 1, turn south on Forest Service Road 893. Travel about 4 miles to Road 675 and follow to Storm Lake (road may or may not be open to vehicles the last mile). The main population (i.e. type locality) is in meadows on the northern shore on both sides of the dirt "jeep trail." Two subpopulations are located in meadows on hills east of Storm Lake along the trail to Twin Lakes.

Site name: Windy Ridge

County: Granite

Legal description: T4N R14W S3 SW1/4, S4 SE 1/4

Elevation: about 7,400 ft.

Directions: From the junction of Forest Service Roads 893 and 675 (see directions to Storm Lake above), continue on 893 approximately 5 miles. The population is in meadows on the ridge which can be seen to the west above the road. These can be reached by walking about 1/2 mile uphill through the woods.

Site Name: One Hundred Acre Meadow

County: Granite

Legal Description: T4N R14W SW1/4, S15 SE1/4, S22 NW1/4

Elevation: 8,200-8,400 ft.

Directions: From the junction of Forest Service Roads 893 and 675 (see directions to Storm Lake above), continue on 893 approximately 2 miles. Just past Dry Creek turn south on Road 8683 and follow to gate. Follow trail (compass and topographic map are recommended due to many forks) about 3 miles to One Hundred Acre Meadow. Plants are widely scattered across the meadow.



## 2. Environment and Habitat

On the Deerlodge National Forest, *B. paradoxum* is found in "genus communities" in the understories of mesic grasslands on well developed soils in the montane and sub-alpine zones. The species was not found in forests or in rockier or wetter meadows which were surveyed. The populations occur on several geologic formations in both upland and basin topographic positions. The largest and healthiest population occurs in near pristine native montane rough fescue grassland. Slides of the habitats are included in Appendix F.

Lidke and Wallace (1993) recently mapped the geology of the north-central part of the Anaconda Range which includes two of the population sites. This area lies near the southernmost known extent of the Sapphire thrust plate and is characterized by thrust faults. The underlaying geology of One Hundred Acre Meadow is mapped as four units of Paleozoic sedimentary rocks including limestones, dolomites, and shales of the Jefferson, Maywood, Hazmark, and Red Lion formations. Windy Ridge lies on the Helena formation which is composed of Middle Proterozoic limy siltstones and limestones of the Belt Supergroup. The Storm Lake area is not included in the mapping area, but similar valleys and lake basins nearby are mapped as Pleistocene Glacial till.

The populations occur on gentle to moderate slopes of all aspects at elevations ranging from 7,400 to 8,500 feet (2,250-2,590 meters). The One Hundred Acre Meadow and Windy Ridge sites are large meadows on exposed ridges, while the Storm Lake population occurs in smaller openings in forest within a steep walled basin. The soils in the area are mapped on a broad scale as Inceptisols with Ustic to Udic moisture regimes and Frigid to Cryic temperature regimes (U.S.D.A. Soil Conservation Service 1978), however, grassland soils are usually classified as Mollisols. The soils of some *Festuca scabrella*/*F. idahoensis* habitats (the habitat type at Windy Ridge and perhaps at One Hundred Acre Meadow) have been classified as Cryoborolls (Mueggler and Stewart 1980). Field observations characterize the soils of the population sites as moderately dry to moist loams with few rocks or stones, and with well developed organic horizons (O and A). *B. paradoxum* was not found in wetter or rockier soils.

Lellinger (1985) indicates that species of *Botrychium* may be favored by a "little disturbance." Lesica and Ahlenslager (1993) suggest that *B. paradoxum*, in particular, may be adapted to "ephemeral habitats." Some preference for slightly disturbed microsites was also noted during this project, however, by far the largest, most dense, and healthiest population was found at the least disturbed site (Windy Ridge). In contrast, One Hundred Acre Meadow, a site highly





disturbed by rodents and game, hosts few, widely scattered, small, chlorotic plants.

On the Deerlodge National Forest, *B. paradoxum* occurs in meadows in small and large openings, from a few to hundreds of acres, in the dominant montane and subalpine forests of the area. Tree species in these zones include *Abies lasiocarpa*, *Larix lyallii*, *Picea engelmannii*, *Pinus albicaulis*, and *Pinus contorta*. The meadows are dominated by grasses and sedges and have a conspicuous forb element. These habitats are normally considered "open" and "exposed," however, the tiny moonworts are in fact understory species, growing underneath, and sheltered by the much taller graminoids and forbs. In all three populations *B. paradoxum* is the most common member of the *Botrychium* genus community. In spite of the diversity of these communities, moonworts are nowhere common. Even at Windy Ridge, the canopy cover they contribute (the degree of dominance) is insignificant and plants are very difficult to find.

The grasslands of Windy Ridge closely resemble the *Festuca scabrella*/*F. idahoensis* habitat type described by Mueggler and Stewart (1980). The near pristine habitat at this site is indicated by the clear dominance of *Festuca scabrella* and an abundance of *Carex raynoldsii*, both species highly sensitive to grazing. One Hundred Acre Meadow may be a degraded version of this habitat type; rough fescue is present, but other fescues (*F. idahoensis* and *F. rubra*) and other native grasses are more common. The smaller openings at Storm Lake are dominated by *Festuca idahoensis* and sedges (including *Carex geyeri*, a species usually associated with forests). At all three sites, *Carex raynoldsii* is subdominant.

A complete list of vascular plants found associated with *B. paradoxum* is presented in Appendix D. In the field, there seemed to be an especially close association with species in the Rosaceae (i.e. *Fragaria virginiana* and *Potentilla* spp.). This may be a coincidence, or a mutual preference for slightly disturbed microsites (decreased competition from graminoids), but, a similar association has been noted between species of *Botrychium* subgenus *Sceptridium* and wild cherries, apples, and strawberries in the eastern U.S. (Lellinger 1985), suggesting a possible mycorrhizal link.

Members of the Ophioglossaceae, including species of *Botrychium*, have no root hairs and are considered to be dependent upon associated endophytic fungi for mineral absorption as well as, presumably, carbohydrate nutrition (Gifford and Foster 1989, Lellinger 1985, Wagner and Wagner 1981). This mycorrhizal relationship, found in both the subterranean gametophyte and the terrestrial sporophyte, is



apparently responsible for allowing the evolution of partially achlorophyllous species such as *B. paradoxum* and the undescribed single fronded form mentioned above (Wagner and Wagner 1981, Wagner, pers. commun.). The species of symbiotic fungi are not known. Because of this obligatory symbiosis, which is poorly understood, species of *Botrychium* cannot be propagated and studied apart from the wild.

### 3. Population biology

The three known occurrences of *B. paradoxum* on the Deerlodge range in area covered from approximately five to one hundred acres and in estimated population numbers from one hundred to thousands of plants. Plants were larger and more mature at the lower elevation Windy Ridge site and smallest and immature at the exposed, higher elevation One Hundred Acre Meadow site. Later phenology may be partially responsible for the small number of plants which were found at One Hundred Acre Meadow. Population trends cannot be determined at this point; the One Hundred Acre Meadow and Windy Ridge populations were discovered during this project, and although the tallies of the Storm Lake population have increased since it was first discovered, this is believed to be an artifact of search intensity and scope. The populations are mapped in Figures 5-7 in Appendix B and Element Occurrence Record printouts are included as Appendix C to this report. Demographic details are as follows:

Site name: Storm Lake

Area occupied by population: ca. 5 acres in 3 subpopulations

Number of individuals counted:

Main population (type locality): 50 counted by 2 people in 4 hours in 1993; 20 counted in 1992 (Rinehart); 9 counted, date unknown, prior to 1981 (Wagner and Wagner)

Other subpopulations: 23 counted by 1 person in 2 hours

Estimated number of individuals: total 350+

Population summary: This is a fairly dense population which covers a small area. Plants were of medium size and vigor at the date of the survey with most spores immature but a few dehiscent. The population is threatened by recreational traffic.

Site name: Windy Ridge

Area occupied by population: ca. 40 acres

Number of individuals counted: 194 by 3 people in 5 hours

Estimated number of individuals: 1,000-10,000

Population summary: The largest known, this is a dense population which covers a large area. Plants were the largest and most vigorous seen, many with mature





dehiscent spores at the survey date. Putative hybrids between *B. paradoxum* and another species were found here.

Site Name: One Hundred Acre Meadow

Area occupied by population: subpopulations widely scattered over 100 acres

Number of individuals counted: 10 by 1 person in 4 hours

Estimated number of individuals: total 100+ ?

Population summary: This consists of a few minute, chlorotic plants widely scattered over a large area. Plants were immature at the survey date. The population is potentially threatened by heavy rodent disturbance and browsing by game.

#### 4. Evidence of threats to survival

As alluded to in the population summaries above, two of three populations of *B. paradoxum* known on the Deerlodge are potentially threatened. Since the species was not described until 1981, the size of the Storm Lake population before that time is not known. Storm Lake is a natural basin with its water level elevated by man made impoundment. The location of *B. paradoxum* in meadows along the shore with eroded banks suggests that there was more potential habitat prior to the building of the dam. In addition, the main population is dissected by a dirt road ("pack trail"), evidence of further historical habitat depletion. Many old firepits and campsites attest to a long history of outdoor recreation around the lake. Recently, the population has faced a new threat. In 1992, a private logging road through section 19 north of the lake was opened to the public, allowing access to two wheel drive vehicles and resulting in intensified recreational use of the site (Rinehart 1992). Prior to this, the lake could be reached only by a rough jeep trail, and most recreationists walked in. In 1993, vehicles parked and turned around and people camped and picnicked within the *Botrychium* habitat. Although there are travel restrictions published (U.S.D.A, Forest Service 1991), these were not enforced in 1993. The Deer Lodge District is apprised of the situation (Gilman, pers. comm.). An additional question requiring consultation is the presence of a patented mining claim and private surface right inholdings associated with the impoundment which may include part of the population area (Rinehart 1992).

The threat to the One Hundred Acre Meadow is entirely different. This site is heavily disturbed by rodent activity and browsing by game (no evidence of livestock grazing was seen). This may be a result of human impacts on game range, or it may be entirely natural. The occurrence of the extremely large population at Windy Ridge in near pristine grassland suggests that *B. paradoxum* is favored by a minimal



level of disturbance. Its rarity may be a result of the paucity of suitable native habitat.

## DISCUSSION

Until recently, many botanists (but not fern specialists) doubted the legitimacy of *B. paradoxum* as a species. Since it was known by only a few individuals scattered over a wide range, they argued that it was probably just an aberrant form of another species. The Wagners (1993) state that teratological forms of *Botrychium* species with transformed trophophores do occur but are very rare. The morphological stability of individual plants of *B. paradoxum*, *B. hesperium* and their putative hybrid, *B. X watertonense* has been documented over several years by monitoring in Alberta (Lesica and Ahlenslager 1993). The discovery of the extremely large population of *B. paradoxum* on Windy Ridge also supports the validity of the species. Although a previously undocumented level of variation is apparent in the Windy Ridge population, evidenced by individuals with more than usual branching (see photocopy of my collection # 5077 in Appendix E), *B. paradoxum* appears to be relatively uniform throughout its range and is probably the easiest of all moonworts to identify.

Further work is needed before recommendations can be made on the conservation status of *B. paradoxum*. This survey was confined to a relatively small area in the vicinity of Storm Lake; the remainder of the Deerlodge National Forest is as yet unsurveyed. If recent reports of the species in northwest Montana are verified then surveys are also needed in that part of the state. Other populations have been "lost." Population trends and fluctuations have not been determined for any sites in the state. In light of these considerations, the Montana Natural Heritage Program has identified a need to pursue *B. paradoxum* survey work throughout its range in Montana, on the Deerlodge, Flathead, and Kootenai National Forests.

A phenomenon apparent to those working with *Botrychium* is the occurrence of "genus communities" (Wagner and Wagner 1983), where species of the same genus tend to grow together in the same apparent habitat. The presence of these communities has resulted in much taxonomic confusion, but, has also been suggested by the Wagners as a means for solving taxonomic problems. If taxa maintain consistent morphological distinctions without forming fertile hybrids (i.e. plants with intermediate morphology), even in mixed populations, then they are species. The level of sympatry in genus communities appears to run counter to the competitive exclusion principle, such that the presence of one *Botrychium* species increases the



probability of finding more species. Because of this phenomenon, future work should survey entire moonwort communities rather than focusing on individual species. Sites are likely to host more than one species of concern, and may harbour undescribed species.

The feasibility of broad range, species (or genus) specific, surveys for such inconspicuous plants may be questioned. However, the success of this project, resulting in tripling the known populations of *B. paradoxum* on the Deerlodge National Forest, speaks highly for this approach. If these plants are not deliberately sought, then populations and even new species are likely to go undetected. The required intensity of searching is not easily integrated with more general botanical surveys, where moonworts, if encountered at all, are usually found only on lunch break.

Windy Ridge is a superlative site which deserves to be preserved. It has significant scientific, aesthetic, and conservation values, both as *Botrychium* habitat and as a rare example of a pristine, montane grassland. The large and diverse moonwort community provides research opportunities which were not available before. Genetic studies of *Botrychium* have been hampered in the past because of a shortage of plant material (Lesica and Ahlenslager 1993). The gametophytes of these species have rarely been seen, and the assumed mycorrhizal relationships remain for the most part undocumented. Windy Ridge could serve as an outdoor laboratory for future *Botrychium* research, and for ecological studies of native grassland ecosystems in general.





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APPENDIX A. Maps showing travel routes and survey areas.

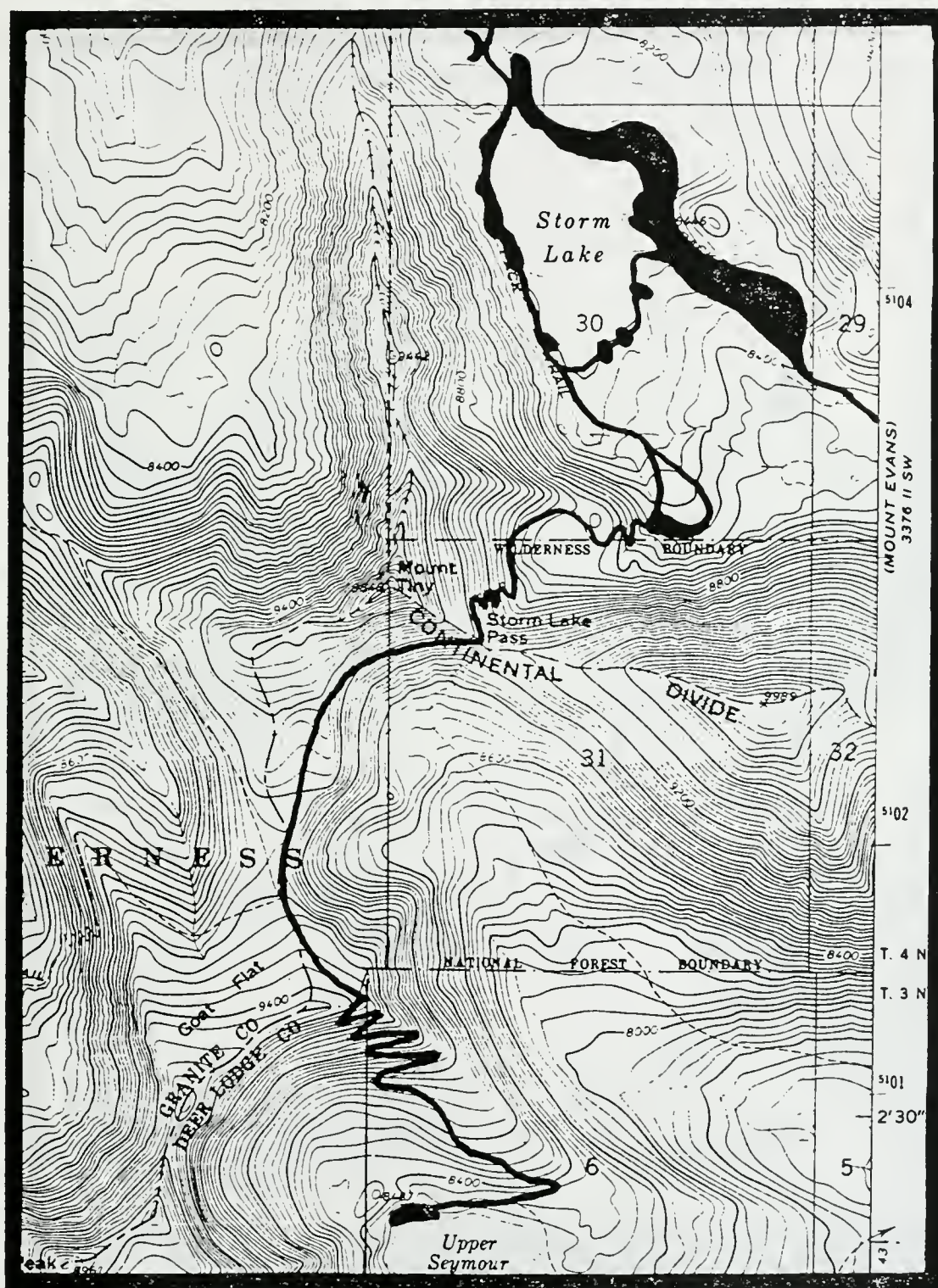


Figure 1. USGS Storm Lake USGS quadrangle (7.5'), showing Storm Lake Basin.





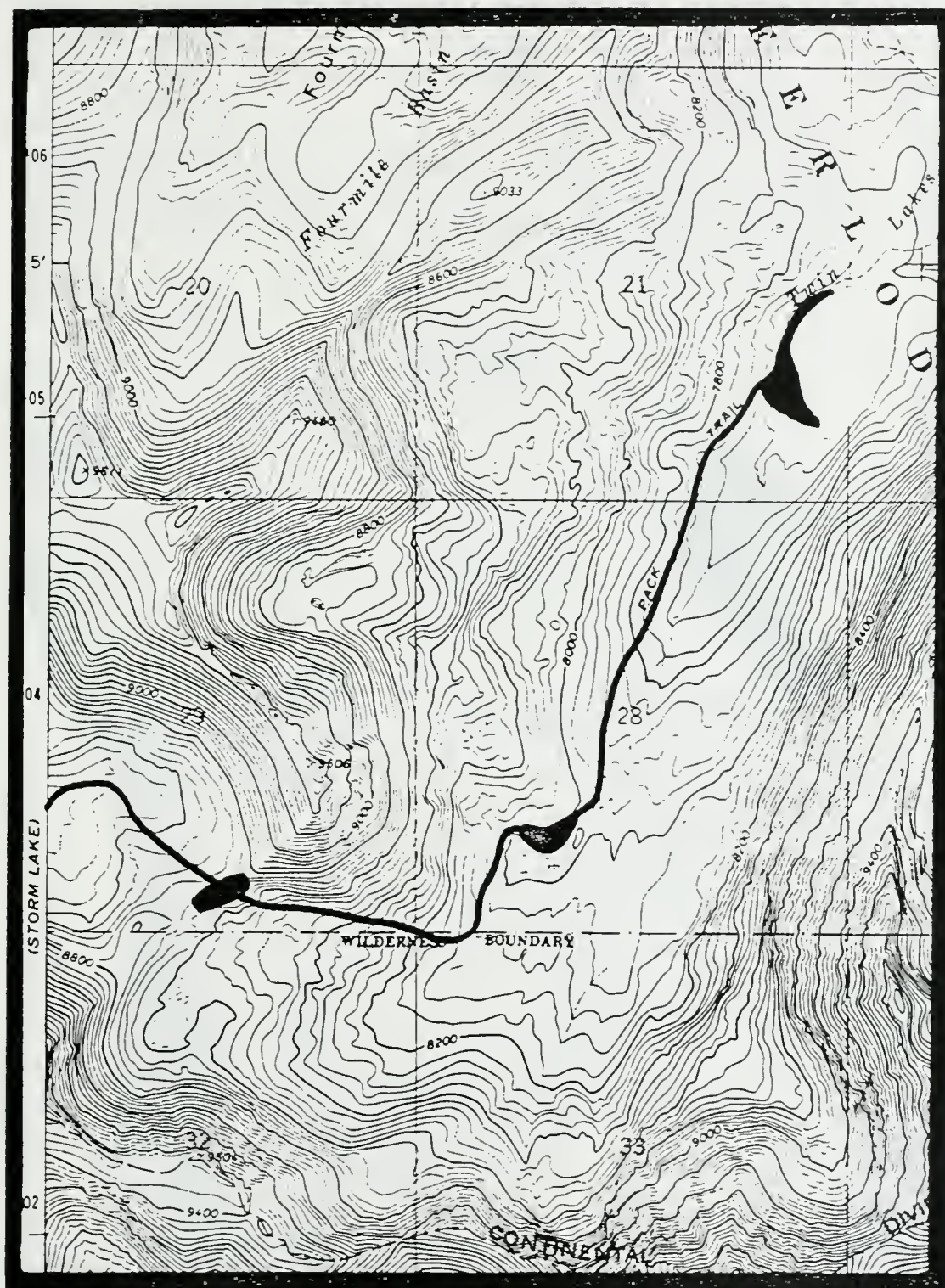


Figure 2. USGS Mount Evans quadrangle (7.5'), showing Twin Lakes Basin.



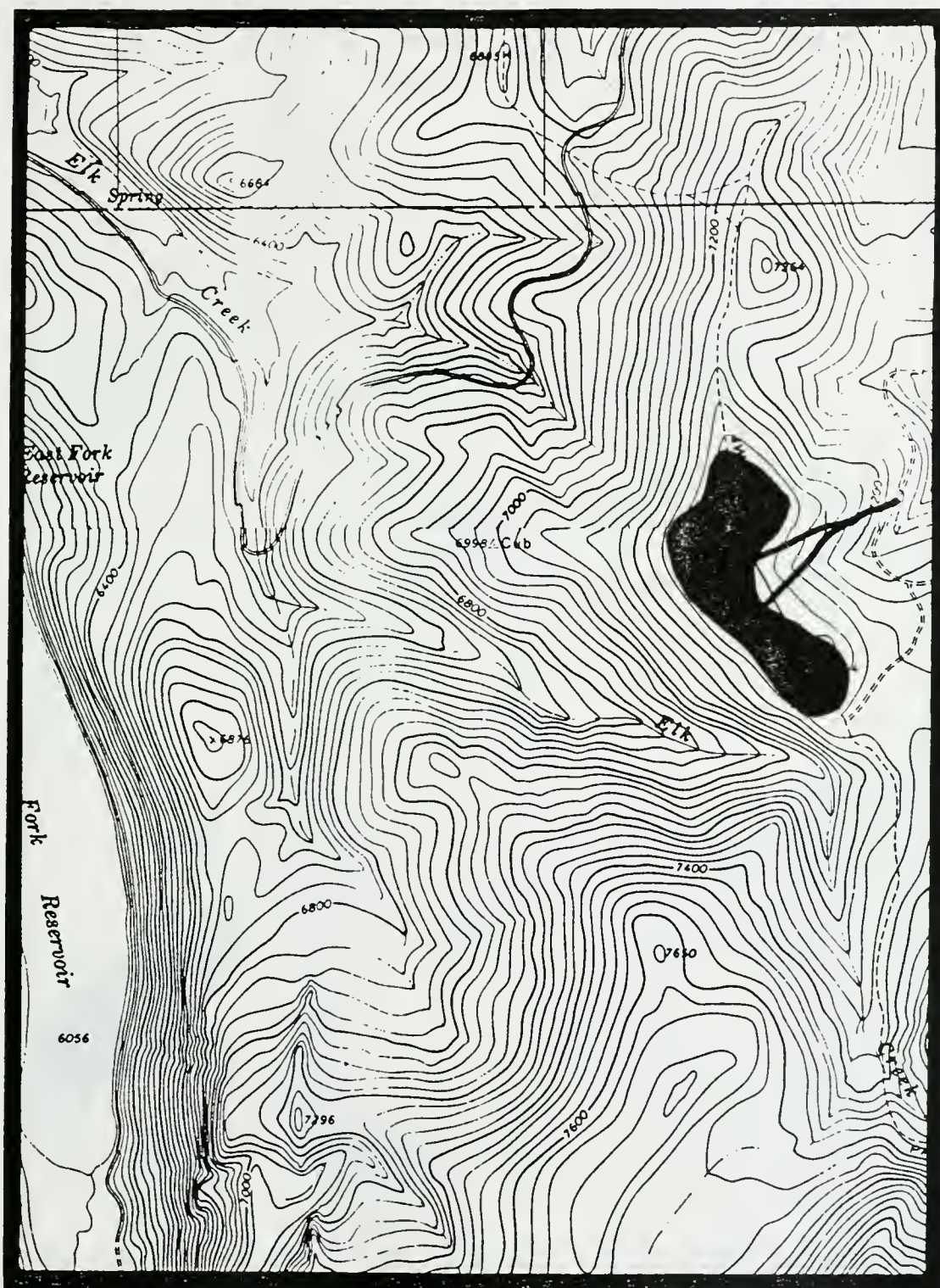


Figure 3. USGS Storm Lake and Georgetown Lake quadrangles (7.5'), showing "Windy Ridge."











APPENDIX B. Maps showing populations of *Botrychium paradoxum*.

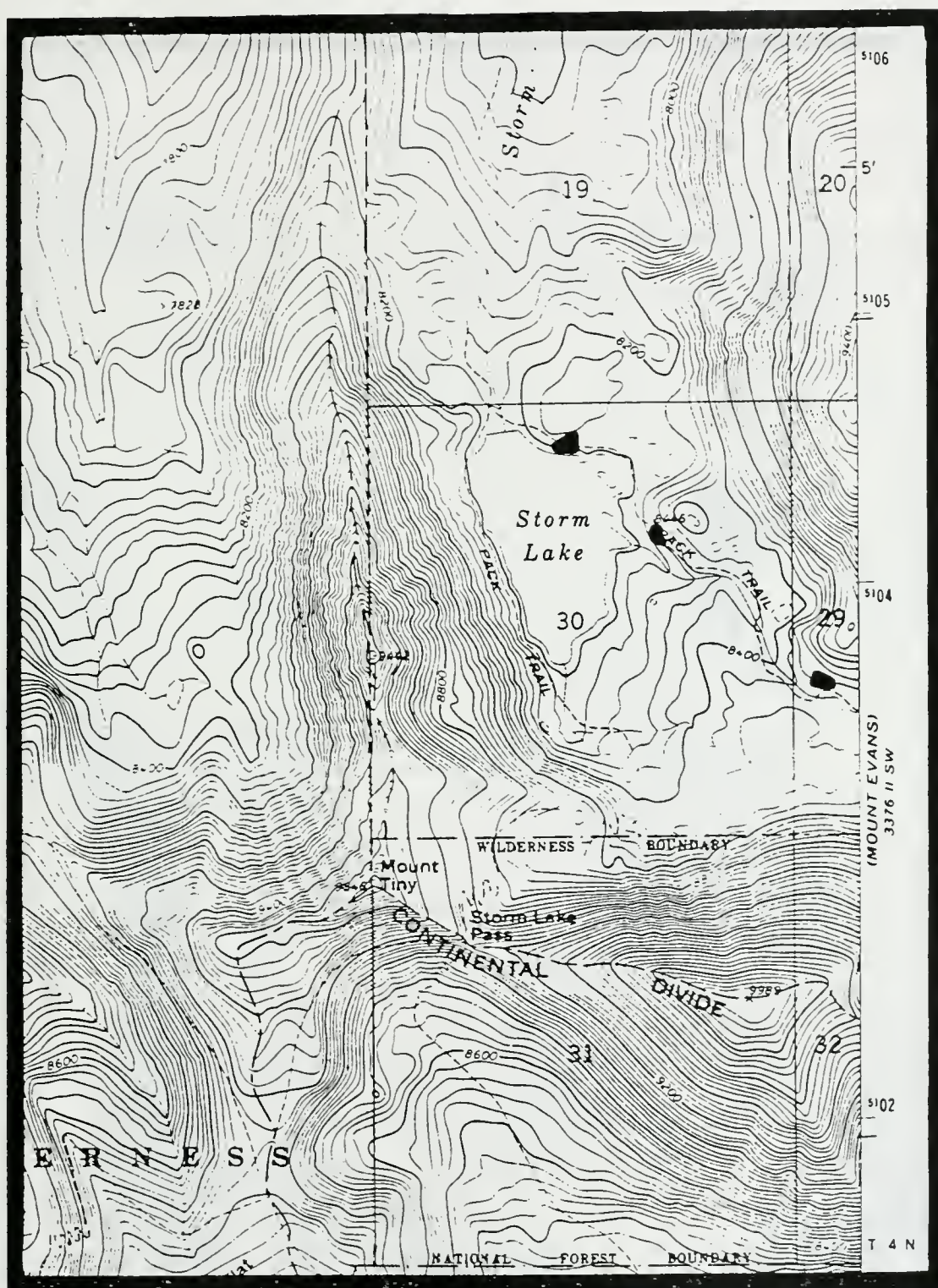


Figure 5. USGS Storm Lake quadrangle (7.5'), showing the three subpopulations in the Storm Lake basin.





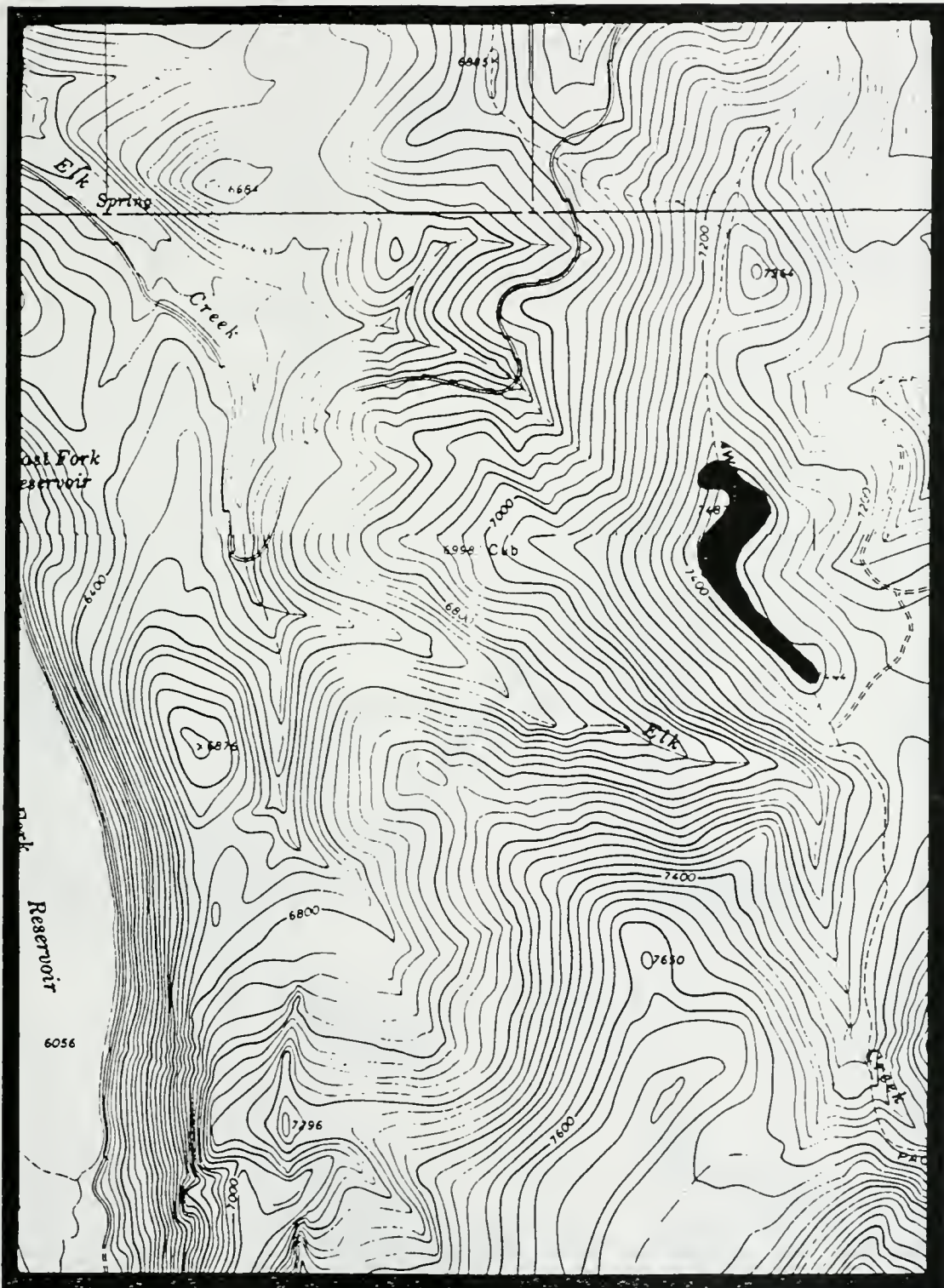


Figure 6. USGS Storm Lake and Georgetown Lake quadrangles (7.5'), showing the Windy Ridge population.





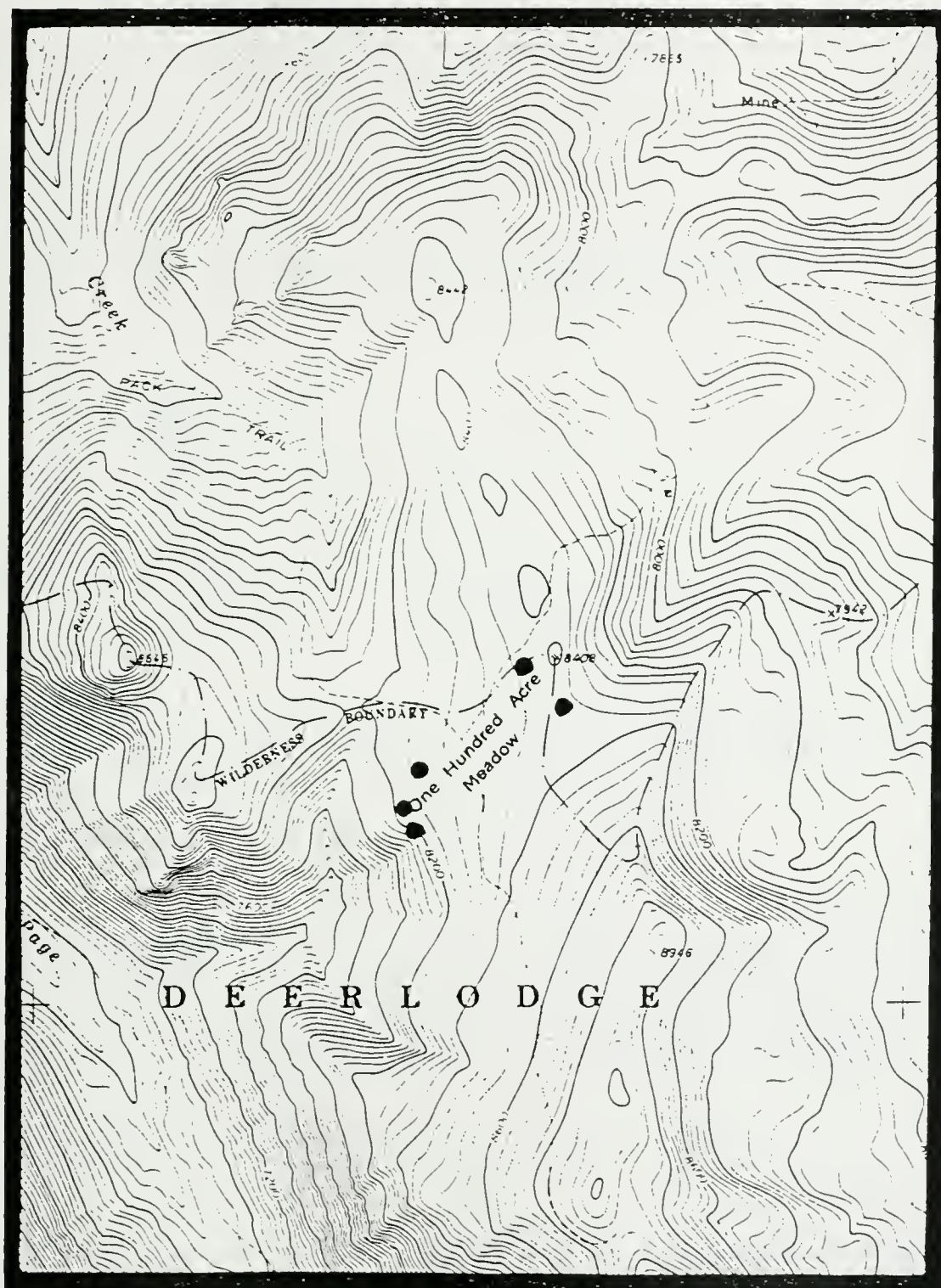


Figure 7. USGS Storm Lake quadrangle (7.5'), showing scattered occurrences in One Hundred Acre Meadow.



APPENDIX C. Element Occurrence Record printouts.



MONTANA NATURAL HERITAGE PROGRAM  
Element Occurrence Record

Scientific Name: BOTRYCHIUM PARADOXUM  
Common Name: PECULIAR MOONWORT

Global rank: G1 Forest Service status: SENSITIVE  
State rank: S1 Federal Status: C2

Element occurrence code: PPOPH010J0.005  
Element occurrence type:

Survey site name: CUB RIDGE  
EO rank: A  
EO rank comments: MAY BE LARGEST POPULATION KNOWN GLOBALLY.  
OUTSTANDING PRISTINE GRASSLAND.

County: GRANITE

USGS quadrangle: STORM LAKE  
GEORGETOWN LAKE

Township: Range: Section: TRS comments:  
004N 014W 03 W2; 04 E2

Precision: S

Survey date: 1993-08-03

Elevation: 7360 - 7480

First observation: 1993-08-02

Slope/aspect: 20% / NW-SE, MOSTLY E

Last observation: 1993-08-03

Size (acres): 40

Location:

CA. 12 MILES WEST OF ANACONDA ON STATE HWY 1, TURN SOUTH ON STORM LAKE ROAD (FS RD 893). KEEP ON ROAD PAST STORM LAKE TURNOFF CA. 5 MILES; MEADOWS ARE VISIBLE FROM ROAD ABOVE TIMBER.

Element occurrence data:

1000+ ESTIMATED, 100% WITH SPORES, SOME DEHISCENT.

General site description:

FESTUCA SCABRELLA GRASSLAND, MESIC MIDSLOPE, LOAM SOIL WITH ORGANIC LAYER. ADDITIONAL SPECIES: FESTUCA IDAHOENSIS, CAREX SP., FRAGARIA VIRGINIANA, POTENTILLA GRACILIS, GEUM TRIFLORUM, ARENARIA CONGESTA, PENSTEMON PROCERA, DANTHONIA UNISPICATA, GENTIANELLA AMARELLA, GENTIANA CALYCOSA, BOTRYCHIUM LUNARIA, BOTRYCHIUM SPP., CAREX FILIFOLIA.

Land owner/manager:

DEERLODGE NATIONAL FOREST, PHILIPSBURG RANGER DISTRICT

Comments:

SURVEYED BY J. VANDERHORST, S. SHELLY AND J. JOY. ESTIMATE OF NUMBERS DIFFICULT; SPECIES REQUIRES VERY DELIBERATE SEARCHING.

Information source: VANDERHORST, J. 1993. [MTNHP FIELD SURVEYS FOR BOTRYCHIUM PARADOXUM ON THE DEERLODGE NATIONAL FOREST.]

Specimens: VANDERHORST, J. (5077). 1993.





MONTANA NATURAL HERITAGE PROGRAM  
Element Occurrence Record

Scientific Name: BOTRYCHIUM PARADOXUM  
Common Name: PECULIAR MOONWORT

Global rank: G1      Forest Service status: SENSITIVE  
State rank: S1      Federal Status: C2

Element occurrence code: PPOPH010J0.006  
Element occurrence type:

Survey site name: ONE HUNDRED ACRE MEADOW  
EO rank: BC  
EO rank comments: MARGINAL POPULATION AND HABITAT.

County: GRANITE

USGS quadrangle: STORM LAKE

Township: Range: Section: TRS comments:  
004N      014W      14      SW4

Precision: S  
Survey date: 1993-08-04      Elevation: 8200 - 8400  
First observation: 1993-08-04      Slope/aspect: 0-20% / WEST, EAST  
Last observation: 1993-08-04      Size (acres):

Location:

CA. 12 MILES WEST OF ANACONDA ON STATE HWY 1, TRAVEL SOUTH ON FS RD 893 PAST TURNOFF TO STORM LAKE TO FS RD 8683. GO SOUTH TO GATE AND FOLLOW TRAIL CA. 3 MILES TO ONE HUNDRED ACRE MEADOW.

Element occurrence data:

ESTIMATED 100+ INDIVIDUALS IN 5 SUBPOPULATIONS, PLANTS SMALLL AND WIDELY SCATTERED. IMMATURE SPORE STAGE.

General site description:

FESTUCA IDAHOENSIS GRASSLAND, MESIC MIDSLOPE, LOAM SOIL, WITH FESTUCA SCABRELLA, LUPINUS WYETHII, POTENTILLA DIVERSIFOLIA, PHLEUM ALPINUM, KOELERIA CRISTATA, FRASERA SPECIOSA, POLYGONUM BISTORTOIDES, BOTRYCHIUM LUNARIA, CERASTIUM ARVENSE, SOLIDAGO SP., SEDUM LANCEOLATUM.

Land owner/manager:

ANACONDA-PINTLER WILDERNESS  
DEERLODGE NATIONAL FOREST, PHILIPSBURG RANGER DISTRICT

Comments:

MARGINAL POPULATION AND HABITAT SEEMS DUE TO EDAPHIC AND BIOLOGICAL FACTORS OTHER THAN DIRECT HUMAN DISTURBANCE. POPULATIONS SHOULD BE VISITED LATER IN SEASON TO DETERMINE IF PHENOLOGY IS A FACTOR IN LOW NUMBERS FOUND.

Information source: VANDERHORST, J. 1993. [MTNHP FIELD SURVEYS FOR BOTRYCHIUM PARADOXUM ON THE DEERLODGE NATIONAL FOREST.]

Specimens: VANDERHORST, J. (5081). 1993.



MONTANA NATURAL HERITAGE PROGRAM  
Element Occurrence Record

Scientific Name: BOTRYCHIUM PARADOXUM

Common Name: PECULIAR MOONWORT

Global rank: G1 Forest Service status: SENSITIVE

State rank: S1 Federal Status: C2

Element occurrence code: PPOPH010J0.007

Element occurrence type:

Survey site name: STORM LAKE

EO rank: C

EO rank comments: AREA HEAVILY-USED FOR RECREATION; USE INCREASING  
AND HABITAT DECLINING.

County: DEER LODGE

USGS quadrangle: STORM LAKE

Township: Range: Section: TRS comments:  
004N 013W 30 NE4NW4, E2; 29 NW4SW4

Precision: S

Survey date: 1993-08-05

Elevation: 8200 - 8480

First observation: 1993-07-30

Slope/aspect: 0-20% / S, SW

Last observation: 1993-08-05

Size (acres): 5

Location:

CA. 12 MILES WEST OF ANACONDA ON STATE HWY 1, TRAVEL SOUTH ON STORM  
LAKE ROAD TO STORM LAKE. MAIN POPULATION IS ON NORTH LAKESHORE ON BOTH  
SIDES OF DIRT ROAD; SUBPOPULATIONS ARE IN MEADOWS ON HILLS WEST OF THE  
LAKE.

Element occurrence data:

TYPE LOCALITY. MAIN POPULATION ESTIMATED TO HAVE 200+ INDIVIDUALS;  
SUBPOPULATIONS ESTIMATED AT 150+ INDIVIDUALS. 100% IN IMMATURE SPORE  
STAGE.

General site description:

MESIC MIDSLOPE AND BOTTOM AND ROLLING UPLANDS, ORGANIC MATERIAL OVER  
LOAM SOIL, WITH FESTUCA IDAHOENSIS, CAREX SPP., FRASERA SPECIOSA,  
ACHILLIA MILLEFOLIUM, PENSTEMON PROCERUS, PEDICULARIS CONTORTA,  
BOTRYCHIUM LUNARIA, JUNCUS DRUMMONDII, POTENTILLA DIVERSIFOLIA,  
BOTRYCHIUM SPP.

Land owner/manager:

DEERLODGE NATIONAL FOREST, DEER LODGE RANGER DISTRICT

Comments:

DRIVING, CAMPING AND TRAMPLING INTENSE AT MAIN POPULATION SITE, WHICH  
IS BISECTED BY A TWO-TRACK ROAD.

Information source: VANDERHORST, J. 1993. [MTNHP FIELD SURVEYS FOR  
BOTRYCHIUM PARADOXUM ON THE DEERLODGE NATIONAL  
FOREST.]

Specimens: VANDERHORST, J. (5057, 5095, 5098). 1993. MONT.



APPENDIX D. Plant taxa associated with *Botrychium paradoxum* on the Deerlodge National Forest. Locations where these taxa were seen is indicated by the abbreviations following the scientific name: OHAM = One Hundred Acre Meadow, SL = Storm Lake, WR = Windy Ridge. Citations are included only when the taxon was not identified by this project. Nomenclature follows Dorn (1984), except for *Botrychium* which follows Wagner and Wagner (1993).

<i>Achillea millefolium</i>	OHAM, SL, WR
<i>Agoseris aurantiaca</i>	SL
<i>Agoseris glauca</i>	SL (Rinehart 1992), WR
<i>Androsace septentrionales</i>	SL, WR
<i>Anemone lithophila</i>	SL
<i>Antennaria microphylla</i>	WR
<i>Antennaria</i> sp.	SL (Rinehart 1992)
<i>Arabis holboellii</i>	WR
<i>Arenaria congesta</i>	SL (Rinehart 1992), WR
<i>Aster alpigenus</i>	OHAM
<i>Astragalus miser</i>	SL (Wagner and Wagner 1981)
<i>Botrychium crenulatum</i>	WR, SL
<i>Botrychium pinnatum</i>	SL
<i>Botrychium lunaria</i>	OHAM, SL, WR
<i>Botrychium minganense</i>	WR
<i>Bromus carinatus</i>	OHAM
<i>Calamagrostis rubescens</i>	SL (Rinehart 1992)
<i>Campanula rotundifolia</i>	WR
<i>Carex atrata</i>	SL (Wagner and Wagner 1981)
<i>Carex filifolia</i>	WR
<i>Carex geyeri</i>	SL
<i>Carex raynoldsii</i>	OHAM, SL, WR
<i>Cerastium arvense</i>	OHAM
<i>Cirsium scariosum</i>	SL (Rinehart 1992)
<i>Danthonia intermedia</i>	SL (Rinehart 1992)
<i>Danthonia unispicata</i>	WR
<i>Elymus spicatus</i>	OHAM, WR
<i>Elymus trachycaulis</i>	OHAM, SL (Rinehart 1992)
<i>Erigeron simplex</i>	OHAM, SL (Wagner and Wagner 1981)
<i>Eriogonum umbellatum</i>	SL, WR
<i>Festuca scabrella</i>	OHAM, WR
<i>Festuca idahoensis</i>	OHAM, SL, WR
<i>Festuca rubra</i>	OHAM
<i>Fragaria virginiana</i>	SL, WR
<i>Frasera speciosa</i>	OHAM, SL, WR
<i>Gaillardia aristata</i>	WR
<i>Galium boreale</i>	WR
<i>Gentiana calycina</i>	WR
<i>Gentianella amarella</i>	WR
<i>Geranium viscosissimum</i>	WR
<i>Geum triflorum</i>	WR





<i>Hedysarum</i> sp.	SL (Rinehart 1992)
<i>Hieracium gracile</i>	OHAM
<i>Hieracium</i> sp.	WR
<i>Juncus drummondii</i>	SL
<i>Koeleria macrantha</i>	OHAM, WR
<i>Ligusticum tenuifolium</i>	SL (Wagner and Wagner 1981)
<i>Linum lewisii</i>	WR
<i>Lithospermum ruderae</i>	WR
<i>Lupinus wyethii</i>	OHAM, SL, WR
<i>Melica spectabilis</i>	OHAM
<i>Pedicularis contorta</i>	SL, WR
<i>Penstemon procerus</i>	SL, WR
<i>Phleum alpinum</i>	OHAM, SL (Rinehart 1992)
<i>Phlox</i> sp.	SL (Rinehart 1992)
<i>Poa</i> sp.	SL
<i>Polygonum bistortoides</i>	OHAM
<i>Potentilla diversifolia</i>	OHAM, SL
<i>Potentilla fruticosa</i>	WR
<i>Potentilla gracilis</i>	SL, WR
<i>Sedum lanceolatum</i>	OHAM, SL (Rinehart)
<i>Selaginella densa</i>	SL
<i>Solidago multiradiata</i>	OHAM, SL (Wagner and Wagner 1981)
<i>Stipa occidentalis</i>	SL (Rinehart 1992)
<i>Stipa viridis</i>	SL (Rinehart 1992)
<i>Stipa</i> sp.	WR
<i>Vaccinium scoparium</i>	SL (Rinehart 1992)
<i>Valeriana sitchensis</i>	SL
<i>Veronica wormskoldjii</i>	SL
<i>Viola adunca</i>	SL



#### APPENDIX E. Photocopies of *Botrychium* specimens with labels.

All determinations are those of the collectors. These are tentative rather than authoritative, except for *B. paradoxum*, which is easily distinguished from all other species. Originally, all plants with trophophores were considered to be *B. lunaria*. However, after consultation with M. Windham and W. Wagner, this position was reconsidered. Wagner and Wagner (1993) state that *B. lunaria* is extremely uniform morphologically, with overlapping pinnae, unlike most of our specimens. Windham identified my collection # 5078a as *B. minganense*, but was puzzled by other specimens with morphology seemingly intermediate between *B. minganense* and *B. lunaria*. These "intermediate" forms key out to *B. crenulatum* in Wagner and Wagner (1993), however, I have not seen pictures or verified specimens of this species; W. Wagner (pers. commun.) did, however, suggest that slide 20 (Appendix F) might be *B. crenulatum*. Windham observed spores of some of our collections, including the oddities. He found that the spores of my collection # 5078b were unusually small, but regular, indicating that these are probably viable spores with a low number of chromosomes. The spores of Shelly's collection # 1822, in contrast, were larger; the plant on the left has regular spores, but the plant on the right has misshapen spores, indicating that it is probably a sterile hybrid. I welcome comments on any of these determinations. The first set of specimens will be deposited at MONT.





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium paradoxum* Wagner

DEER LODGE COUNTY T4N R13W S30 NW1/4  
Anaconda Mountains: Storm Lake, ca. 15  
air miles WSW of Anaconda.

Meadows around lake with Idaho fescue,  
sedges, forbs, and moonworts.

Type locality. 50 plants counted by  
two people in 4 hrs.

30 July 1993

Elev. ca. 8,200 ft.

Jim Vanderhorst # 5057  
with Sherry Vogel







Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY T4N R13W S30 NW1/4  
Anaconda Mountains: Storm Lake, ca. 15  
air miles WSW of Anaconda.  
Meadows around lake with Idaho fescue,  
sedges, forbs, and moonworts,  
including *B. paradoxum* (coll. #  
5057)

30 July 1993

Elev. ca. 8,200 ft.

Jim Vanderhorst # 5056  
with Sherry Vogel





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium lunaria* (L.) Swartz

DEER LODGE COUNTY T4N R13W S 30

Anaconda Mountains: Storm Lake, ca. 15  
air miles WSW of Anaconda, just  
below dam.

Meadows with Idaho fescue, sedges,  
forbs and moonworts. Growing with *B.*  
*crenulatum* (coll. # 5058b.).

31 July 1993

Elev. ca. 8,200 ft.

Jim Vanderhorst # 5058a.





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY                      T4N R13W S 30  
Anaconda Mountains: Storm Lake, ca. 15  
air miles WSW of Anaconda, just  
belowe dam.

Meadows with Idaho fescue, sedges,  
forbs and moonworts. Growing with *B.*  
*lunaria* (coll. # 5058a.).

31 July 1993

Elev. ca. 8,200 ft.

Jim Vanderhorst # 5058b.







Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY T4N R13W S30

Anaconda Mountains: Storm Lake, ca. 15  
air miles WSW of Anaconda.

Meadows above lake with Idaho fescue,  
sedges, forbs, and moonworts.

31 July 1993

Elev. ca. 8,200 ft.

Jim Vanderhorst # 5059





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY T4N R13W S30 SE1/4  
Anaconda Mountains: between Storm Lake  
and Storm Lake Pass, ca 15 air miles  
WSW of Anaconda.

Subalpine meadows with moonworts.

1 August 1993

Elev. ca. 8,400 ft.

Jim Vanderhorst # 5067





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium paradoxum* Wagner

DEER LODGE COUNTY    T4N R13W S30 NE1/4  
Anaconda Mountains: hills west of Storm  
Lake, ca. 15 air miles WSW of  
Anaconda.

Sedge/fescue meadow with moonworts.  
Estimated 100 plants.

6 August 1993

Elev. ca. 8,300 ft.

Jim Vanderhorst # 5095







Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY T4N R13W S30 NE1/4  
Anaconda Mountains: hills west of Storm  
Lake, ca. 15 air miles WSW of  
Anaconda.

Sedge/fescue meadow with moonworts  
including *B. paradoxum* (coll. #  
5095).

6 August 1993

Elev. ca. 8,300 ft.

Jim Vanderhorst # 5096





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY    T4N R13W S30 NE1/4  
Anaconda Mountains: hills west of Storm  
Lake, ca. 15 air miles WSW of  
Anaconda.

Sedge/fescue meadow with moonworts  
including *B. paradoxum* (coll. #  
5095).

6 August 1993

Elev. ca. 8,300 ft.

Jim Vanderhorst    # 5097





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium paradoxum* Wagner

DEER LODGE COUNTY T4N R13W S29 SW1/4  
Anaconda Mountains: between Storm Lake  
and Storm Lake/Twin Lakes divide,  
ca. 15 air miles WSW of Anaconda.  
Sedge/fescue meadow with moonworts in  
understory including coll. # 5099.  
Ten individuals counted in ca. 1/2  
hour, est. population = 100.

6 August 1993

Elev. ca. 8,450 ft.

Jim Vanderhorst # 5098







Ophioglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

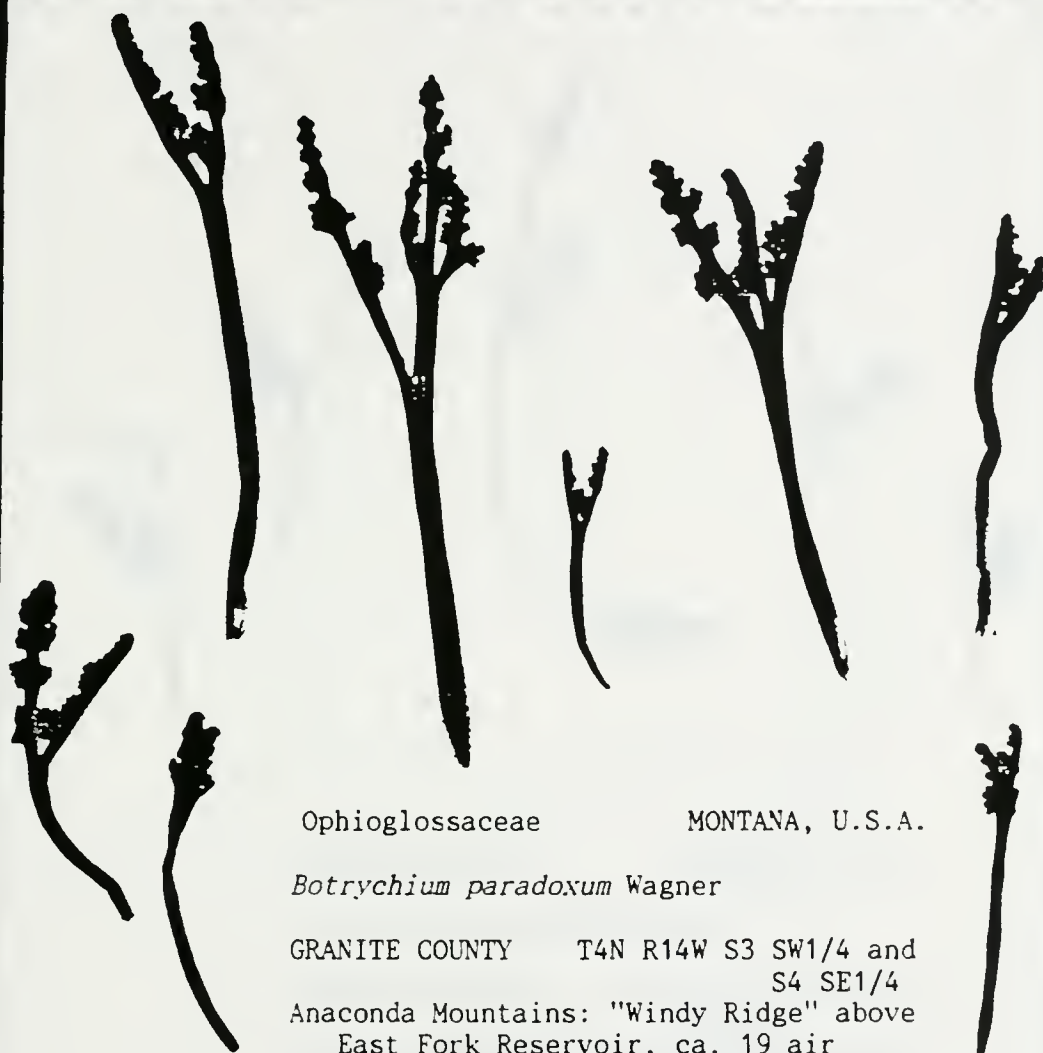
DEER LODGE COUNTY T4N R13W S29 SW1/4  
Anaconda Mountains: between Storm Lake  
and Storm Lake/Twin Lakes divide,  
ca. 15 air miles WSW of Anaconda.  
Sedge/fescue meadow with moonworts in  
understory including *B. paradoxum*  
(coll.# 5098).

6 August 1993

Elev. ca. 8,450 ft.

Jim Vanderhorst # 5099





Ophioglossaceae

MONTANA, U.S.A.

*Botrychium paradoxum* Wagner

GRANITE COUNTY T4N R14W S3 SW1/4 and  
S4 SE1/4

Anaconda Mountains: "Windy Ridge" above  
East Fork Reservoir, ca. 19 air  
miles W of Anaconda.

Pristine montane grasslands dominated  
by rough and Idaho fescues with  
moonworts in understory of grasses.  
Population consists of thousands of  
individuals and covers over 40  
acres.

2 August 1993

Elev. ca. 7,450 ft.

Jim Vanderhorst # 5077





Ophioglossaceae MONTANA, U.S.A.

*Botrychium minganense* Viet.

GRANITE COUNTY T4N R14W S3 SW1/4 and  
S4 SE1/4

Anaconda Mountains: "Windy Ridge" above  
East Fork Reservoir, ca. 19 air  
miles W of Anaconda.

Pristine montane grasslands dominated  
by rough and Idaho fescues with  
moonworts, including *B. paradoxum*  
(coll. # 5077) in understory.

3 August 1993 Elev. ca. 7,450 ft.

Jim Vanderhorst # 5078a  
with J. Stephen Shelly and John Joy





MONTANA, U.S.A.

*Botrychium* sp.

GRANITE COUNTY      T4N R14W S3 SW1/4 and  
S4 SE1/4

Anaconda Mountains: "Windy Ridge" above  
East Fork Reservoir, ca. 19 air  
miles W of Anaconda.

Pristine montane grasslands dominated by rough and Idaho fescues with moonworts, including *B. paradoxum* (coll. # 5077) in understory.

This form was uncommon but seen more than once. One fertile lamina, no sterile lamina, small spores.

3 August 1993

Elev. ca. 7,450 ft.

Jim Vanderhorst # 5078b

with J. Stephen Shelly and John Joy





FLORA OF MONTANA  
MONTANA NATURAL HERITAGE PROGRAM

*BOTRYCHUM LUNARIA* (L.) Sw.

GRANITE CO.

Anaconda-Pintlar Range, "Windy Ridge," ca. 2 air miles east of East Fork Reservoir, adjacent to the head of Blodgett Gulch; ca. 18 air miles west of Anaconda.

T4N, R14W

SECTION 4, east 1/2

ELEVATION: 7,400'

Uncommon; in near-pristine montane grassland, with *FESTUCA SCABRELLA*, *F. IDAHOENSIS*, *FRAGARIA VIRGINIANA*, *BOTRYCHUM PARADOXUM*.

3 August 1993

J. Stephen Shelly, Jim Vanderhorst, and John Joy

1822



Ophioglossaceae

MONTANA, U.S.A.

*Botrychium* sp.

GRANITE COUNTY T4N R14W S14,15,22,23

Anaconda Mountains: One Hundred Acre

Meadow, ca. 17 air miles W of  
Anaconda.

Montane grasslands with heavy rodent  
activity and game browsig, growing  
with *B lunaria* and *B. paradoxum*  
(coll. # 5081).

Minute, chlorotic plants.

4 August 1993

Elev. 8,200-8,400 ft.

Jim Vanderhorst # 5082







Ophipoglossaceae

MONTANA, U.S.A.

*Botrychium crenulatum* Wagner

DEER LODGE COUNTY                      T4N R13W S21

Anaconda Mountains: Upper Twin Lake,

ca. 13 air miles WSW of Anaconda.

Opening in woods with sedges, grasses,  
and moonworts.

6 August 1993

Elev. ca. 7,700 ft.

Jim Vanderhorst # 5101



APPENDIX F. Photographic slides. Slides 1-14 taken by Jim Vanderhorst, slides 15-20 taken by John Joy.

- Slide 1. Storm Lake, *B. paradoxum* type locality from across the bay, dam visible at far left.
- Slide 2. Storm Lake type locality, *Botrychium* habitat on both sides of dirt road ("pack trail").
- Slide 3. *B. paradoxum* from site shown in slide 2.
- Slide 4. *B. paradoxum* from site shown in slide 2.
- Slide 5. Group of *B. paradoxum* from site shown in slide 2.
- Slide 6. *B. pinnatum* (W. Wagner, pers. commun.) from site shown in slide 2.
- Slide 7. *B. lunaria* f. *incisum* (W. Wagner, pers. commun.) from site shown in slide 2.
- Slide 8. *Botrychium* sp. (*minganense* ?) from site shown in slide 2.
- Slide 9. Hills just east of Storm Lake. *B. paradoxum* habitat.
- Slide 10. *B. paradoxum* from site in slide 9.
- Slide 11. *B. paradoxum* habitat above trail between Storm Lake and Storm Lake/Twin Lakes Divide.
- Slide 12. One Hundred Acre Meadow, *Botrychium* habitat.
- Slide 13. One Hundred Acre Meadow, *Botrychium* habitat.
- Slide 14. *B. paradoxum* from One Hundred Acre Meadow.
- Slide 15. Windy Ridge *Botrychium* habitat.
- Slide 16. Shelly and Vanderhorst searching for moonworts on Windy Ridge, posterior shot
- Slide 17. *B. paradoxum* from Windy Ridge.
- Slide 18. *B. paradoxum* from Windy Ridge.
- Slide 19. Single fronded *Botrychium* from Windy Ridge.
- Slide 20. Probably *B. minganense* or *B. crenulatum* (W. Wagner, pers. commun.) from Windy Ridge.







